# TOPIC 08 – ACIDS/BASES
# 8.3 – STRONG AND WEAK ACIDS AND BASES

IB Chemistry

T08D02

# 8.3 Strong and weak acids and bases - 2 hours

- 8.3.1 Distinguish between strong and weak acids and bases in terms of the extent of dissociation, reaction with water and electrical conductivity. (2)
- 8.3.2 State whether a given acid or base is strong or weak. (1)
- 8.3.3 Distinguish between strong and weak acids and bases, and determine the relative strengths of acids and bases, using experimental data. (2)

# 8.3 – Strong and Weak Acids

- From IB: Students should consider hydrochloric acid, nitric acid and sulfuric acid as examples of strong acids, and carboxylic acids and carbonic acid (aqueous carbon dioxide) as weak acids.

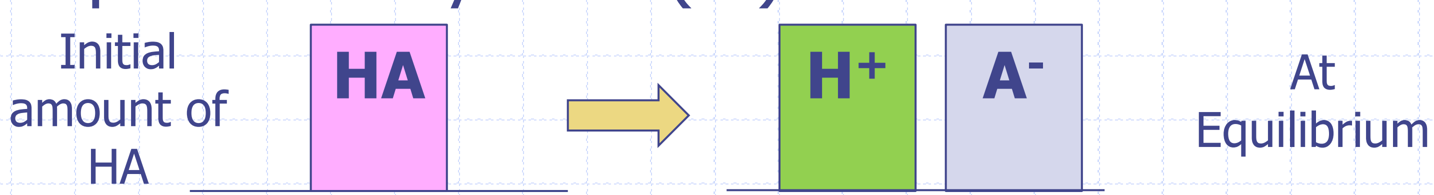
| Strong Acids | Weak Acids |
|---|---|
| $HCl$ | Carboxylic Acids (ex: $CH_3COOH$) |
| $HNO_3$ | Carbonic Acids ($H_2CO_3$ or $CO_2(aq)$) |
| $H_2SO_4$ | $H_3PO_4$ |
| $HClO_4$ | |

# 8.3 – Strong and Weak Acids

- When a strong acid dissolves, nearly all the acid molecules react with water to produce $H^+$ ions
  - They have a very high $K_c$ value
    - $HA \rightarrow H^+(aq) + A^-(aq)$

      0%     ~100%
    - $HA + H_2O(l) \rightarrow H_3O^+(aq) + A^-(aq)$

      0%     ~100%
  - The equilibrium is so far to the right for strong acids that we use a yields symbol (→) instead of an equilibrium symbol (⇌)



# 8.3 – Common **Strong Acids**

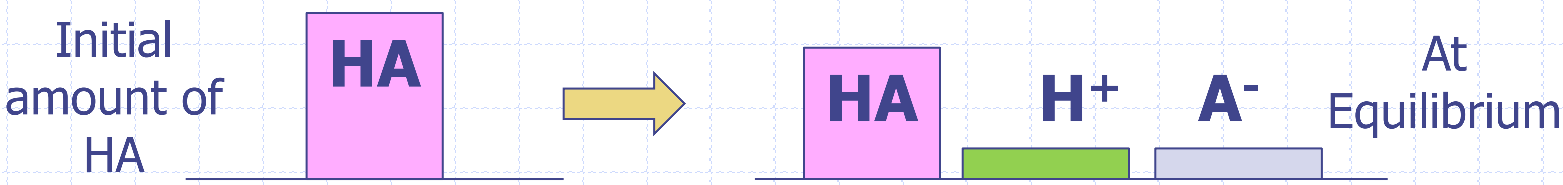
- **Hydrochloric Acid**:
  - $HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$
- **Nitric Acid**:
  - $HNO_3(l) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$
- **Sulfuric Acid**:
  - $H_2SO_4(l) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$
- **Perchloric Acid**:
  - $HClO_4(l) + H_2O(l) \rightarrow H_3O^+(aq) + ClO_4^-(aq)$
- Generally, monoprotic acids are weaker with about 1% reacting with water molecules to release $H^+$ ions in solution. The above are exceptions

# 8.3 – Weak Acids

- The general formula for a weak acid is:
  - $HA \rightleftharpoons H^+(aq) + A^-(aq)$

    99%   ~1%
  - $HA + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

    99%   ~1%



# 8.3 – Common Weak Acids

- **Ethanoic Acid**:
  - $CH_3COOH(l) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+$
- **Carbonic Acid**:
  - $CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$
  - The compound of "carbonic acid" does not actually exist as it cannot be isolated.
  - Attempts to isolate it result in the formation of carbon dioxide and water
- **Phosphoric Acid**:
  - $H_3PO_4(l) + H_2O(l)\ H_2PO_4^-(aq) + H_3O^+(aq)$

# 8.3 – Strong vs Weak Acids

- Equal [conc] of strong and weak acids can be easily distinguished:
  - Strong acid has more $H^+$ ions, hence lower pH
    - Universal indicator, pH probe, pH paper
  - Strong acids are more conductive
    - Conductivity probe, circuit, etc
  - Strong acids react more vigorously with metals, metal oxides, metal carbonates and bicarbonates
  - Strong acids have a more (-)$\Delta H$ of neutralization
  - The titration curves of strong acids differ from that of weak acids

# 8.3 – Strong vs Weak Acids

- **Do not** confuse strong and weak with dilute and concentrated
  - Concentrated = high molarity of pure acid (S or W)
  - 0.1 M HCl (strong) vs 0.1 M $CH_3COOH$ (weak)
  - Acid strength does not change when a solution is diluted, only the concentration does

| | **0.1 mol dm$^{-3}$ HCl(aq)** | **0.1 mol dm$^{-3}$ $CH_3COOH$(aq)** |
|---|---|---|
| $[H^+(aq)]$ | 0.1 mol dm$^{-3}$ | ~0.0013 mol dm$^{-3}$ |
| pH | 1.00 | 2.87 |
| Conductivity | High | Low |
| Reaction Rate with Mg | Fast | Slow |
| Reaction Rate with $CaCO_3$ | Fast | Slow |

# 8.3 – Strong and Weak Bases

- From IB: Students should consider all group 1 hydroxides and barium hydroxide as strong bases, and ammonia and amines as weak bases.

| Strong Bases | Weak Bases |
|---|---|
| LiOH | $NH_3$ |
| NaOH | Amines (ex: $C_2H_5NH_2$) |
| KOH | |
| RbOH | |
| CsOH | |
| $Ba(OH)_2$ | |

# 8.3 – Strong and Weak Bases

- Strong and weak bases can be described just as acids
  - **Strong bases** undergo nearly 100% ionization or dissociation when in dilute aqueous solution
  - **Strong bases** have high pH values and high conductivity
    - $BOH + (aq) \rightarrow OH^{-}(aq) + B^{+}(aq)$

      0% ~100%
  - All bases **not** of groups I and II are considered to be **weak bases**
    - $BOH + (aq) \rightleftharpoons OH^{-}(aq) + B^{+}(aq)$

# 8.3 – Equations for Bases

- **Strong Bases**
  - Equilibrium lies to the right, very high $K_c$ value
  - $NaOH(s) + (aq) \rightarrow Na^{+}(aq) + OH^{-}(aq)$
  - $KOH(s) + (aq) \rightarrow K^{+}(aq) + OH^{-}(aq)$
  - $Ba(OH)_2(aq) + (aq) \rightarrow Ba^{2+}(aq) + 2OH^{-}(aq)$
- **Weak Bases**
  - Equilibrium lies to the left, low $K_c$ value
  - $NH_3(g) + (aq) \rightleftharpoons NH_4^{+}(aq) + OH^{-}(aq)$
  - $C_2N_5NH_2(g) + (aq) \rightleftharpoons C_2H_5NH_3^{+}(aq) + OH^{-}(aq)$

# 8.3 – $Ca(OH)_2$ as a base

- As mentioned before, only bases that are soluble in water are considered to be alkaline
- Calcium hydroxide is only slightly soluble in water but is very effective at producing $OH^-(aq)$ ions when in solution
  - It's a group II hydroxide like $Ba(OH)_2$
  - Therefore, $Ca(OH)_2$ is often considered a strong base but is very dilute in solution
  - $Ca(OH)_2(s) + (aq) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$